Soil Moisture status and its responses on Land Uses and water conservation measures in the Loess plateau Region

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1. Abstract

Soil moisture plays a very important role on vegetation growing and water cycling in arid and semi-arid area. It was affected and characterized by land cover and land uses as well as soil water conservation activities. Based on data from long-term survey of the soil moisture in depth of 0-4m at a 20cm interval during past 20 years at more than areas in loess plateau region, the soil water statues and its difference between land uses and landfarms had been outlined. Soil moisture passively reflected rainfall pattern, therefore, soil turned to be drier alone with rainfall decreasing from south to north. There were obvious differences in soil moisture profiles between land uses. It showed farm land > pasture land > shrub community land > arboreal forest. In drying season, the soil water were decreased to a very low point. Most of forest land uses could result in a drier soil profile comparing with crop land. The soil moisture in rainfall>550mm region was much better than that of rainfall in 400-550mm where the arboreal forest's growing could be restricted. Result figures illuminated the soil water conservation measures effects on soil moisture. The order of the soil water storage under water conservation measures was fish-scale pit>narrow level belt>slope land>terrace.

Key words：Loess hilly and gully region; land use; water conservation measure; soil moisture dynamic;

2. Introduction

In the loess hilly region, the spatial combination of physiognomy, vegetation and climate results in the spatial discrepancy of soil moisture distribution (Xu Xue-xuan,et al. 2003, Fu Be-jie, et al. 1999). The different land uses can influence the soil moisture distribution. This influence will provide scientific gist for rational utilization of soil water resource and environmental construction in west. In the past, because of the excessive utilization of soil water, the sustaining supply capacity of soil water declined, and the benefit of vegetation planting also reduced. For example, the output of Astragalus adsurgens Pall. and clover dropped markedly even became extinct after 5-6 years(Wang Li, et al. 2001); some artificial forest such as acacia land lost environmental and economical benefit, became "little geezer" forest (Hou Qing-chun, et al.1999). These instances corresponded to the exhausted soil water resource in deep layer (2~8m), and the essential reason is that the vegetation construction didn't according to the law of nature(YANG Wen-zhi, et al.1999,2004). Different land uses make the deficient of soil water different (Xu Xue-xuan,et al. 2003). As a result, to study the effect of soil water according to the distribution and the species of vegetation, then choice the vegetation that adapt to the soil water environment, can provide instructional gist for the collocation and distribution of vegetation in area(Yang Wen-zhi,2001).

In this research, Fuxian, Yan'an, An'sai and Guyuan were chosen respectively representing regions with different perennial precipitation level, the soil survey conducted in many sits including: the transition area of the loess plateau ravine region and loess hilly region (Fuxian, Yan'an), loess hilly region (Yan'an, An'sai, Guyuan). Concerning the vegetation characteristics, the study area included the forest zone and forest-pasture zone. the ordinal precipitation were including as about 580mm, 550mm（the forest zone）,500mm, 450mm, (the forest-pasture zone). All data were collected during the period 1985-2007, most of which were in 2000.

3. Method of research

Soil water survey was conducted mainly in the four counties (Fuxian, Yan'an, An'sai, Guyuan). The soil was sampled by handle gauge and dried by the oven to get the gravimetric water content each sit at 0-4m depth mainly in a 20cm interval. In some sits the depth extended to 9m to show the contrast of soil water profile in deep layer.

The sites for soil water sampling were within 10~25°slopes in the midpart of a slope. The on sit vegetation should basically represent the mean level of the whole slope. According to the difference between soil water profiles, the influencing of vegetation on soil water was analyzed.

In the study area, the rainfall was regionally different, varied in a range in 580mm-400mm, which covered the forest and forest-pasture zone. The study paid much attention to soil water in each rainfall level under different land uses. the study analyzed the effects of vegetation by comparing the difference in soil water of each land use.

Soil water content after the extreme dry year was also studied to check if the soil profile could provide water normally and adequately.

4. Results and discussions

4.1 Soil water status from the south to the northwest

4.1.1 Soil water status of different land uses in south loess hilly region

The research had done in Fuxian, where the rainfall is around 580mm. Figure 1 showed that, by the end of continuous drought years, (1) in the study area, the soil water utilization of arboreal forest and shrub community was markedly better than crop land, the soil water profile showed that the water content in the order: farm land＞secondly land＞acacia land. (2) The distinct difference was under 200cm, it showed that the maximum depth of soil water utilization of crop was 0~200cm. (3) The maximum utilization depth was different for each kind of land use. It respectively was 0~2m in crop land, about 6m in acacia forest. Because of the existence of deep root species in secondly land, its utilized depth was deeper than 7m.

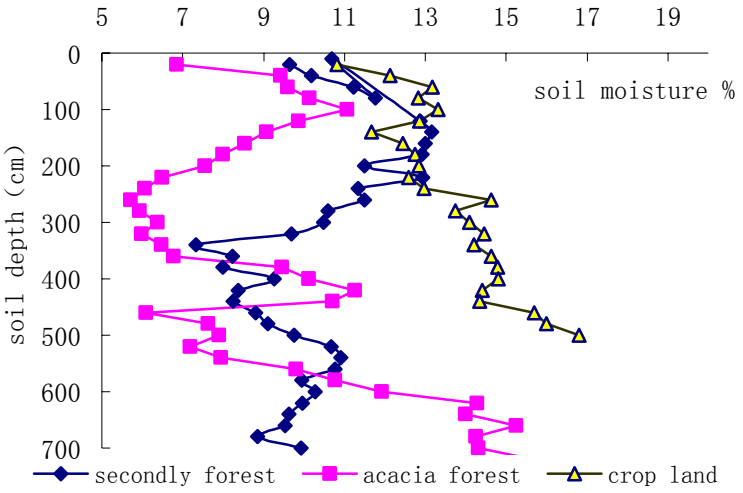

Figure 1 Soil moisture status of several vegetations in Fuxian

4.1.2 Soil water status in the forest-pasture transitional zone

Yan'an, An'sai located in the transition area of loess hilly region and loess gully region, and the transition area of forest zone and forest-pasture zone with rainfall ranges from 580mm to 500mm. The effect of vegetation on soil water was therefore different from Fuxian. The research showed some results in table 1.

The rainfall within Yan'an, An'sai county was markedly different along with the latitude decrease varying from 400mm to 550mm, therefore much attention had been paid in this area. In April of year 2000, after extreme drought year (1999), the soil water in 0~2m layer of different land uses and vegetation in north, middle and south An'sai had been systematically surveyed. The result showed in table 1. that the order of soil water was north＜middle＜south, but the discrepancy of land use was little because of the long period drought. At the same time, the soil water almost was lower than wilt moisture, the vegetation could hardly made use of the soil water. This condition would intimidate the normal growth of vegetation. The soil water of crop land in north was markedly lower, and its soil moisture was near acacia land and grassland. The vegetation had made full use of the soil water of upper layer. If the soil water wasn't resumed well, and the measures of water conservation weren't adopted, the vegetation construction would be difficult to be succeeded.

From the table 1, the soil water of dry season after drought year was markedly low; the grassland and crop land in south was appreciably higher than 10%, but the soil water of acacia land was lower than fuxian, the latter was higher than 8%. The result showed that the soil water with the same vegetation in these two areas was markedly different.

Table 1 The contrast analysis of soil moisture under different land uses in An'sai (cm, g/g%)

types	depth of soil(cm)	acacia land	Grass land	terrace land	crop slop land	average
N slope in north (400-450mm)	0-50	4.70	5.28	4.70	4.67	4.84
	0-100	5.31	5.41	5.31	4.35	5.09
	100-200	5.85	5.49	5.85	4.57	5.44
	0-200	5.54	5.44	5.54	4.44	5.24
S slope in middle (450-500mm)	0-50	5.37	4.93	5.53	4.90	5.19
	0-100	5.10	4.69	6.08	4.82	5.17
	100-200	6.29	4.32	7.68	5.28	5.89
	0-200	5.64	4.54	6.74	5.01	5.48
N-S slope in south (500-550mm)	0-50	6.29	9.24	7.85	7.40	7.69
	0-100	6.70	11.52	9.06	7.89	8.79
	100-200	6.15	11.38	13.86	11.48	10.72
	0-200	6.47	11.46	11.06	9.38	9.59

As a result, the soil water of transition area was markedly lower than that of forest zone; the soil water of upper

layer was nearly exhausted in extreme drought year, and the discrepancy of soil water under different vegetation in 0~2m became little. All soil water profile of drought year tended to be the same.

4.1.3 The effect of vegetation on soil water in forest-pasture zone

The perennial precipitation of Guyuan in west of loess hilly was about 450mm, and the vegetation was forest-grass. the effect of vegetation had been analyzed on soil water (data of year 2000). The result was showed in figure 2.

From figure 2, it showed that the order of soil water in 0~3m was that crop land ＞ almond land ＞ poplar land ＞ seabuckthorn land ＞ caragana land. Only the soil water of caragana land and seabuckthorn land was lower than wilt moisture in 70~200cm, became the layer that the soil water was difficult to make use of. Because of the worse growth condition of poplar land, the soil water remained in poplar land was better than that of shrub community. Because the almond grown sporadically, its density was low too, so the soil water of whole layer was high. It was different from the high soil water of shrub land in forest zone. The main reason was that the growth condition of arbores was so bad that the arbores grown worse and the consumption of soil water reduced in transitional zone. The shrub community in this area grown well, and consumed more soil water, so its soil water was lower than arboreal forest. Some researches had the same conclusion(Hou Qin-chun, et al. 1991,Mu Xing-ming, et al. 2002, Wang Guo-liang, et al. 2002, Wang Meng-ben, et al. 2001,).

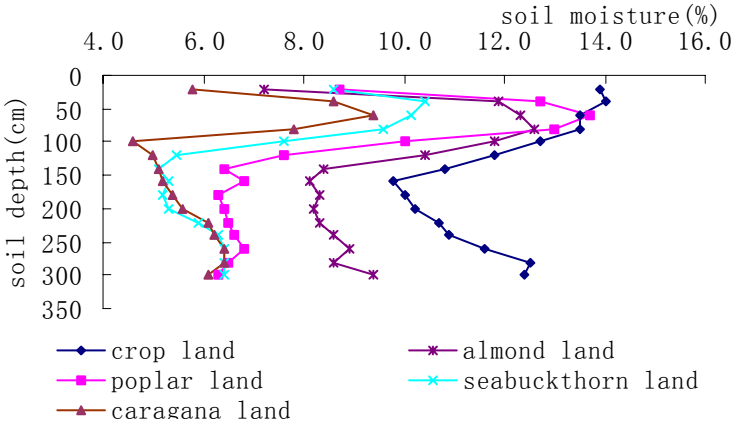

Figure 2 Soil moisture of vegetation land in Guyuan

4.2 soil water under difference measures of conservation

Based on survey in Yan'an, soil water content of 4 key measures of water conservation had been analyzed in fig.3 and table 2, where many measures of soil and water conservation were used to enlarge rainfall to be restored in the soil. The data were from Oct. 2000. The slope land was the 25° sunny slope with grass covered 60% of land. Other 3 key measures were very common in this region.

Fig.3 showed a obvious margin between water conservation methods and slope land. Compare to othe 3 kinds of landform, the terrace land has the most effective result in water conservation, that was why it became the most common measures in the whole loess plateau. The order then went to narrow bench land, and then the fish-scale pit land. The fig. 3 also showed that soil water content of the 3 ways was higher in the whole profile, especially for the terrace land.

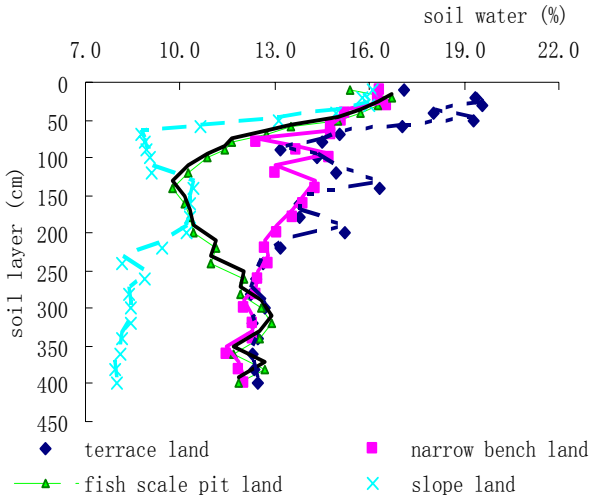

Figure 3 Soil water under difference measures of water conservation

Table 2 showed that fish-scale pit could block a little bit more water than slope land, but largely less than that of the other two. In the layer of 1-2m, fish-scale pit had nearly the same level of water content as slope land.

Bench land could block much rainfall to soil, just a little less than that of terrace land, therefore it had been taken as the most cost-effective methods to protect water and soil loss in the loess plateau.

The biggest margin of soil water in the 4 measure was in layer of 0.5-2.5m. in layer 1-2m, the margin between the fish-scale pit, slope land and the forepart two measures became the largest.

Table 2 Soil water differed by water conservation measures (cm, g/g%)

soil layer	terrace	bench land	Fish-scale pit	slope land
0-1m	16.7	15.0	13.9	12.2
1-2m	14.7	13.8	10.3	9.9
2-3m	13.1	12.6	11.5	8.9
3-4m	12.4	12.6	12.4	8.2
1-4m	13.3	13.0	11.4	9.0
0-4m	14.2	13.5	12.0	9.8

5. Conclusion

The soil water profile of crop land, forest land and grassland was different. The obvious difference was lay in deep layer. Because crops could hardly fully use the soil water in deep layer, so that the profile of soil water in crop land was better than that of forest and grass land.

The order of soil water in different rainfall region was nearly the same, that was in this order: crop land, grass land, shrub community, and arboreal forest from high to low; but in forest grassland (Guyuan), because of the bad condition of arbores growth, the soil water was maybe lower than shrub land.

The soil water in forest zone was markedly better than in transition zone.

The *caragana* and *seabuckthorn* consumed more soil water. In different areas of loess hilly, their profile of soil all had the dry layer. But the soil water of almond land, peach tree, secondly shrub and grassland was comparatively better, but these vegetation also excessively made use of the soil water.

Due to lack of rainfall, soil water became a very rare resource, many cost-effective measures had been used in the whole region, among those, terrace and bench land were the very common ways. The fish-scale pit could also increasing soil water content, but it was very limited. We should adopt some measures to help restore vegetation in this region.

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